

Q: Is the cosmic microwave background a shell around us? Or are the microwaves everywhere in the universe?

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A: The cosmic microwave background (CMB) radiation fills the universe and travels in all directions. As we see it from here in satellite maps, it is about equally bright in all directions, and that's one of the main reasons we know it's cosmic. The Greek word is *isotropic*, which means the same in every direction.

Assuming we are not at a special spot, that also means that the radiation is the same brightness in all locations throughout the universe, at least if you could take a measurement at the same time at each location (13.8 billion years after the Big Bang). The maps we make of the CMB brightness show it as it is now arriving here from everywhere else, but if you wait a billion years, there still will be radiation arriving from everywhere else.

There is one sense in which we see the CMB coming from an apparent shell around us. The universe became fairly suddenly transparent when it was about 380,000 years old and the temperature was down to about 3,000 kelvins. So we see each CMB photon as coming from the last place it bounced off an electron. It's a little like looking at the Sun. We see the Sun's light coming from features on what seems to be a surface, but the Sun doesn't have a surface — it is gaseous. Right now we are receiving light that escaped from the Sun 500 seconds ago, and if we wait a day we will still be receiving light from the Sun that has taken 500 seconds to arrive. It's like that with the CMB too, except it has taken 13.8 billion years for the light to arrive here instead of 500 seconds.

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